Memorandum

To: U.S. Environmental Protection Agency (EPA), Office of Research and Development

From: Ann Maest, PhD, Stratus Consulting Inc.

Date: 12/21/2012

Subject: Comments on Peer Review of EPA's Draft Bristol Bay Watershed Assessment

1. Introduction

This memorandum provides comments on water quality, geochemical, and mitigation measure issues discussed in "Final Peer Review Report, External Peer Review of EPA's Draft Document: An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" (Versar, 2012). The main topic areas that I address are best practice prevention and mitigation measures, failure scenarios, and uncertainties related to the Biotic Ligand Model and the use of water quality standards.

I hope that these comments are useful to EPA as they prepare their final Watershed Assessment.

2. Best Practice Prevention and Mitigation Measures

Mitigation measures were addressed in Charge question 12 to the draft Watershed Assessment peer reviewers (p. 6):

> *Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?*

Many reviewers noted that the discussion of mitigation measures and mine operation in the draft Watershed Assessment needs to move from "good practice" to "best practice." As noted by Dirk van Zyl (p. 23):

> *The main body of the report emphasizes on a number of occasions (such as page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices."*

An important part of best practices is tailings management, as Dirk van Zyl discusses on p. 40. Other reviewers, including David Atkins, Steve Buckley, Charles Slaughter, John Stednick, and

Roy Stein conclude that the mitigation measures or the no-failure scenarios are not well described (Charge question 3; pp. 45–48).

I agree with the reviewers' comments. To address the many reviewer comments on this topic, I suggest that EPA add a section after Section 4.2 (i.e., a new 4.3, or a part of 4.2) that describes the types of best practice prevention and mitigation measures that could be used in the mine scenario presented in the draft Watershed Assessment. Unfortunately, Appendix I of the draft Watershed Assessment (Conventional Water Quality Mitigation Practices for Mine Design, Construction, Operation, and Closure) does not discuss best practices for mine operation or mitigation and prevention measures, and does not even reference the primary source on the topic used most often by the mining industry (INAP, 2012). I suggest that EPA keep their hypothetical mine plan the same in terms of facilities and extraction methods, and use an approach that closely follows INAP (2012) and Golder Associates (2012; see Chapter 8) to describe best practices. INAP (2012) also includes a table showing whether the best practice methods are proven and where they might not work as well [see Table 6-7: Summary of Prevention and Mitigative Measures and Climate Considerations in INAP (2012)]. Some of the conditions mentioned in the table are relevant to the Pebble area, which has a climate most similar to the Koppen classification D (Continental severe mid-latitude) or E (Polar). Some of the mitigation and prevention measures have not been fully demonstrated in all of the climate types, and EPA could note these limitations in the final Watershed Assessment.

3. Failure Scenarios

Failure modes or scenarios were addressed in Charge questions 3 and 5 (p. 5):

> *EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?*
>
> *Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?*

Some reviewers note that something between "no failure" and "catastrophic failure" should be described that would include events with a higher probability that would result in smaller-scale failures. For example, John Stednick wrote (p. 19):

> *The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures.*

Rather than using only "no-failure" and "failure" scenarios in the risk assessment, a better approach might be to classify and describe the potential environmental effects using the following categories:

- *Effects from presence of mine facilities.* Under the assumed mine scenario in the draft Watershed Assessment, placement of wastes, excavation of the open pit, and mine dewatering would result in the loss of headwater streams and wetlands, as described in portions of Section 4.3 of the draft Watershed Assessment.

- *Failures resulting from lack of adequate characterization.* Failures related to the lack of adequate hydrologic or geochemical characterization are described in detail in Kuipers and Maest (2006), which has now been peer reviewed by EPA. Such failures could involve movement along faults that were not identified before mining began. This failure mode is not currently included in the draft Watershed Assessment, but it has occurred at the Buckhorn Mine in northern Washington State. As noted in my July 23, 2012 comments to EPA on the draft Watershed Assessment, the mine's consultants attributed increases in mine-related contaminants in streams near the Buckhorn Mine to movement of water stored in the underground mine along a large fault. Other characterization failures may include incorrect placement of potentially acid-generating (PAG) waste on the non-PAG waste rock piles and water balance errors.

- *Failures of prevention and mitigation measures.* Even if prevention and mitigation measures are installed and operated properly, they can fail. Examples of prevention and mitigation measure failures that are relevant to the mine scenario in the draft Watershed Assessment include the release of contaminated leachate from failure of the monitoring system (including pumps) and failure of the capture zone. Both could result in the appearance of mine-related contaminants in downgradient groundwater and surface water. The draft Watershed Assessment does, however, describe a water collection and treatment failure in Section 6.3. As described in comments from Cameron Wobus the analysis could be updated using the MIKE SHE hydrologic modeling results described in the Wobus et al. (2012) report, which was recently peer reviewed by EPA. Another important failure mode that could occur but that was not described in the draft Watershed Assessment is a failure of the capture zone created by mine dewatering. Such a failure has occurred at the Buckhorn Mine in northern Washington State ($395,000 fine issued;

http://www.ecy.wa.gov/news/2012/240.html). This type of failure could occur seasonally if groundwater levels rise and overwhelm dewatering efforts; it could be a longer-term failure if the dewatering system does not work well in fractured bedrock.

- *Catastrophic failures.* Two catastrophic failures are described in Sections 6.1 (tailings dam failure) and 6.2 (pipeline failure) of the draft Watershed Assessment. Those descriptions could be moved into the new section describing catastrophic failures in the final report.

The perfect performance of prevention and mitigation measures is not guaranteed (see Kuipers and Maest, 2006). As noted by some of the draft Watershed Assessment peer reviewers, EPA does not currently have a basis to assume that the use of best practices at a new mine will prevent adverse environmental effects (Roy Stein, p. 63):

> *I am discouraged when I understand that history (in the eyes of the mining company) is not a good predictor of the future because technology has taken us so much farther along, reducing risks of whatever failure significantly. In my view, this is a specious argument and one that should be roundly put to bed by the authors of this report. History is indeed the absolute best predictor of the future and technological changes that have occurred since past mines must be absolutely and critically evaluated to determine if indeed risks do go down. This is a serious issue and one that should be addressed with some rigor by the authors.*

In addition, no study has been conducted that demonstrates that newer mines using "best practices" pollute less than current or recently operated mines or than mines using "good" practices. As noted by Dirk van Zyl (p. 40):

> *To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best."*

Absent such a study, EPA should assume that the information on failures from recently operated and current mines are representative of failures that could occur at a new mine using best practices. In fact, the burden of proof should be on the operator to demonstrate that current best practices improve environmental performance.

4. Uncertainties Related to the Biotic Ligand Model and the Use of Water Quality Standards

In his general comments (p. 22), William Stubblefield suggests that EPA conduct additional research to "*improve our understanding of copper toxicity and to ensure that the regulatory standards are, in fact, appropriate for their intended use*" and resolve the uncertainty mentioned in the draft Watershed Assessment about the protectiveness of the biotic ligand model (BLM) for species of concern in Bristol Bay. He also lists areas of additional research, including investigating the toxicity of metal mixtures and the sensitivity of salmon species of concern in Bristol Bay (p. 70).

I agree that the research identified could be helpful, and we are currently in the planning phase of conducting some of the testing recommended in the peer review document. However, I do not believe that EPA needs to conduct this research before the Watershed Assessment is finalized. At the end of Section 5.3.2.2 in the draft Watershed Assessment, EPA discusses some of the uncertainties associated with the BLM. In addition to those listed in Section 5.3.2.2, another uncertainty associated with BLM is its use in low-hardness waters. We are currently evaluating this issue (Morris et al., 2012a, 2012b; Appendix A).

Because of the uncertainties associated with the use of the BLM at the Pebble site, EPA could complete their watershed assessment by relying on, or at least reflecting, Alaska's existing water quality criteria. The draft Watershed Assessment appears to rely almost exclusively on the BLM-based criteria.[1] For example, EPA calculates acute and chronic copper criteria for each watershed in Table 5-18 of the draft Watershed Assessment, yet there is no similar table for the existing State criteria (they are mentioned once in the text on p. 5-53). For the final Watershed Assessment, EPA could create a table comparing background copper and dissolved organic carbon concentrations and hardness values in each drainage against BLM and State criteria. The table could also include the percentage of the analyses in each drainage that show exceedences of each criterion. Showing mean values and ranges, ideally at several distinct locations, would address many of the reviewers' comments that request more information on the temporal and spatial variability of water quality parameters is needed in the final Watershed Assessment (see, e.g., comments from John Stednick, pp. 30 and 55, and Dennis Dauble, p. 68).

1. The BLM-based criteria are exceeded in some Pebble site waters at some times, as noted by Paul Whitney on p. 50. Most of these locations are in headwater reaches, yet highly sensitive fish and macroinvertebrate species are thriving in headwater locations, as noted on p. 5-16 of the draft Watershed Assessment.

References

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Morris, J. A. Maest, A. Craven, and J. Lipton. 2012b. Site-specific Issues with Applying the BLM to Evaluate Cu Toxicity: Overestimation of Cu-DOC Complexation and Model Anomalies in Low Hardness Waters. Society for Environmental Toxicology and Chemistry: 33rd annual meeting, Long Beach, CA, November 11-15.

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Wobus, C.W., R. Prucha, A. Maest, and D. Albert. 2012. Potential Hydrologic and Water Quality Alteration from Large-scale Mining of the Pebble Deposit in Bristol Bay, Alaska. Prepared for The Nature Conservancy, October.

A. Copies of Morris et al., 2012a, 2012b Abstracts

The Biotic Ligand Model: Unresolved scientific issues and site- and species-specific effects on predicted Cu toxicity

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Topic: Water Quality, Water Balance, Water Management, Water Treatment.

Oral presentation requested.

The EPA has approved use of the Biotic Ligand Model (BLM) to calculate site-specific water quality criteria. Although the BLM is an important advance that considers all major-element chemistry, in a number of situations the BLM appears to be under protective of sensitive aquatic organisms, particularly salmonids. The issues discussed relate to the WHAM V model and the biotic ligand binding constants used in the BLM.

At hardness values <20 mg L^{-1} as $CaCO_3$, the BLM predicts lower Cu, Zn, and Cd toxicity to rainbow trout than at somewhat higher hardness values. The effect is more pronounced with increasing dissolved organic carbon (DOC) concentrations but is noticeable at DOC values as low as 1 mg L^{-1}. The lower predicted toxicity appears to be related to modeled metal binding between the gill and DOC. At very low hardness values, the BLM predicts that Cu and other metals will preferentially bind with DOC, and modeled LC_{50} values decrease with increasing hardness. At higher hardness values, the LC_{50} is predicted to rise by ~4 or 5 μg Cu L^{-1} for each ~ 20-mg L^{-1} increase in hardness. There is no empirical evidence to suggest that aquatic biota are more tolerant of metal concentrations at low hardness values, and the hardness-based equations do not produce this peculiarity. A number of headwater streams around the country have low-hardness waters, and use of the BLM at those sites should proceed with caution.

The log K value of the gill, which controls Cu binding to the gill, is set at 7.4 for Cu and rainbow trout in the BLM. No values are currently included in the model for other salmonid species. Plots of Cu LC_{50} and gill log K values show that a gill log K of 7.4 is close to the inflection point for predicted toxicity, and even small changes in gill log K can produce large changes in predicted copper toxicity. The uncertainty in gill log K values should be explored, including the extent to which they change with different salmonid species.

The Biotic Ligand Model (BLM) was used to estimate concentrations of free Cu (Cu^{2+}) in site water near the Pebble deposit in Alaska and to predict the toxicity of Cu^{2+} to rainbow trout. Visual MINTEQ was also used to predict Cu^{2+} concentrations using conditional log K values derived from actual site waters. The BLM predicted considerably lower free Cu concentrations under modeled site conditions. The discrepancy could be reconciled by decreasing DOC input values to the BLM by ~7 times (actual stream value was 2.17 mg L^{-1}). Other researchers have suggested that inputting one-half the measured DOC concentrations to the BLM yields a better fit with fish toxicity data in some cases. These findings and the issues discussed above suggest that the BLM appears to apply higher net Cu-dissolved organic matter (DOM) binding strengths across a range of Cu:DOM ratios and water qualities found in many site waters.

Presentation Type:
Platform

Track:
Aquatic Toxicology and Ecology

Session:
Fate and Effects of Metals: Aquatic Biological Perspective

Abstract Title:
Site-specific issues with applying the BLM to evaluate Cu toxicity: overestimation of Cu-DOC complexation and model anomalies in low hardness waters

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Abstract:

The Biotic Ligand Model (BLM) was used to estimate concentrations of Cu^{2+} in site waters in Alaska and to predict the toxicity of copper to rainbow trout. Visual MINTEQ was also used to predict Cu^{2+} concentrations using conditional log K values for Cu^{2+}-dissolved organic matter (DOM) binding derived from the same site waters over a range of total copper concentrations. The BLM predicted considerably lower Cu^{2+} concentrations than our empirical data when the total copper concentrations were greater than 1 μg L^{-1} (2×10^{-8} M) under modeled site conditions. The discrepancy could be reconciled by decreasing the dissolved organic carbon (DOC) input values to the BLM by ~7 times (actual stream value was 2.17 mg C L^{-1}). Other researchers have suggested that inputting one-half the measured DOC concentrations to the BLM yields a better fit with fish toxicity data in some cases. These findings suggest that the BLM appears to apply stronger net Cu^{2+}- DOM binding across a range of Cu:DOM ratios and water qualities found in many site waters, which could result in an under-prediction of copper toxicity.

Additionally, the BLM applies a log K value of 7.4 for the strength of copper binding to the gill (biotic ligand) for rainbow trout. Plots of total copper LC_{50} and gill log K values show that a gill log K of 7.4 is close to the inflection point for predicted toxicity, and even small changes in gill log K can produce large changes in predicted copper toxicity.

Finally, at hardness values <20 mg L^{-1} as $CaCO_3$, the BLM predicts lower Cu toxicity to rainbow trout than at somewhat higher hardness values. The lower predicted toxicity appears to be related to differences in modeled metal binding affinities between the gill and DOC. At very low hardness values (~5 mg L^{-1} as $CaCO_3$), the BLM predicts that copper will preferentially bind with DOC, and modeled LC_{50} values decrease with increasing hardness (e.g., 5-20 mg L^{-1} as $CaCO_3$). At higher hardness values (e.g., >25 mg L^{-1} as $CaCO_3$), the LC_{50} is predicted to rise by ~4 or 5 μg Cu L^{-1} for each ~ 20-mg L^{-1} increase in hardness. There is no empirical evidence to suggest that aquatic biota are more tolerant of metal concentrations at low hardness values, and the hardness-based water quality criteria equations do not produce this peculiarity. A number of headwater streams around the country have low-hardness waters and use of the BLM at those sites should proceed with caution.